I. Detailed Description of the Project (Technical)

The first objective of this work is to develop smart agricultural system using IoT, Artificial Intelligence (AI) along with drone system.

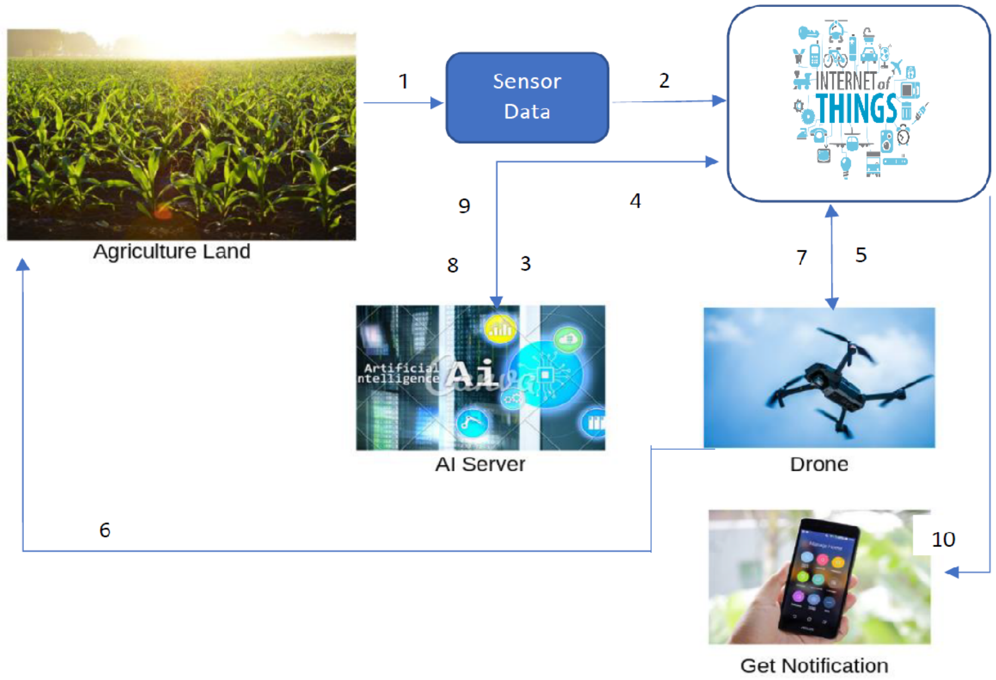

Fig. 1 Proposed model for smart agriculture system.

The model will use Unmanned Arial Vehicle (Drone) to monitor the agricultural land where different kind of sensors such as soil moisture, humidity, pressure and temperature sensors etc have been deployed. The data collected by the sensor will be sent to AI server through IoT. Apart from this, satellite data will also be considered as an input in the AI system. AI will, then, analyze the sensor and satellite data and it will prioritise the monitoring requirement of crops by drone. Now, the drone will monitor the crops condition on the priority basis and will send the information to AI server. Finally, AI will analyze the cause and problem and it will pass on the solution to the concerned person for rectification.

II. Introduction and Background

Agriculture is practiced throughout the world. We use many agricultural products every day, from the clothes we put on in the morning to the sheets we sleep under at night. When you think of agriculture, think of the five F,s: food, fabric, forestry, farming, and flowers. However, agriculture suffers a lot due to climate change as it has an adverse impact on agriculture. This also affects farmer's lives as well as the prices of agricultural products rises. This is a serious problem for the economy which really needs a solution.

With increase in the global population, we need at least 70% increase in the food production to feed the population on the earth by 2050. If we talk of nourishing the people, then the situation becomes even much more alarming. It is because of the ever-decreasing fertility of the land and ever-receding water levels. This poses a serious problem in front of scientist and engineers to solve the food problem. The solution to this food problem lies in developing an efficient farming system which requires less and less input and yields more and more output.

The aim of the project is to provide simple technology-based solutions to various challenging problems of the agricultural sector, being faced by the farmers in day-to-day life. We can call it Smart Farming/Smart Agriculture. Smart Farming is a farming management concept using modern technology to increase the quantity and quality of agricultural products.

The proposed model consists of mainly three parts: (i) Artificial Intelligence (AI) (ii) Internet of Things (IoT) enabled sensors (iii) Drone with a suitable camera and GPS system. AI will have access to GPS, soil scanning, data management, and Internet of Things technologies. By precisely measuring variations within a field and adapting the strategy accordingly, the concerned person can greatly increase the effectiveness of pesticides and fertilizers and use them more selectively.

The project focuses on the development of the technology framework that includes various emerging technologies such as IOT, AI and drone system fabrication. As the different types of sensors will be installed in agricultural lands, tha will collect real-time data and send it to the AI server for further process. The sensors will mainly measure humidity and temperature of surroundings of the land, the humidity of soil, the air quality index to determine percentage of O_2, CO_2 level and other different gases level to help AI to know better health of crop according to the environment changes. Fire-detecting sensor will help the concerned person to take immediate action to prevent it as soon as possible. We will make small gadgets which will include all the required sensors for collecting different parameters in the agricultural land. These gadgets will be installed at different parts of the land, the data from these sensors will be sent to a central cloud by which all gadgets will collect different parameters for the same land and prepare a database. This will be sent to AI for processing and getting the overview of that area of land. The same procedure will be executed for all agricultural land in a village to make a Smart Agricultural Monitoring System based on IoT.

Small Gadgets can be installed in large area of a village and may be enabled with IoT through internet. For covering a large connectivity of gadgets by internet we can use Wifi module in small gadget and enable Wi-fi routers to cover large area, for which large number of Wifi routers will be required. This will lead to high cost and high power consumption. We may also use 4G module then we will have to install it in each and every gadget, which will also increase the consumption of power. Moreover, we would have to get monthly subscription for this which will be very costly. Therefore, the solution to reduce cost and consumption power is to use P2P technology, by which we can cover the large area with high connectivity. This P2P technology will be able to give access to every small gadget to pass the sensor information to AI server with real time accuracy.

We need to develop precision agriculture. Precision agriculture means that collection of exact data about the lands (e.g. what is the humidity of soil three feet below surface), so that we can plan the type of crops we want to grow. Precision agriculture also means the scientific approach to use water and pesticides wherever required. If farmers come to know which area needs more water and which area needs less water, then accordingly they can use their natural resources. On the one side, this will increase the productivity and on the other side, this will reduce the cost. Similar is the case with pesticides and other fertilizers. Other example is if we know why a seed grow differently in the different area of the land, then, we can take better decision as to which seed we need to have for our own land. So the solution lies in the optimum use of the resources and also at the right time.

The solution to the problem of precision farming lies in the use of emerging technologies such as AI and IoT-enabled sensors. AI needs lots and lots of data and based on the machine learning and processing, is capable of taking a right decision. Therefore, the big problem is the need of big amount of data for AI to train the machine. There are various resources of data for AI such as data collected from drone and IoT enabled sensors.

IOT INTEGRATION FLOW(COMPLETE)

Description of design parameters/technical details involved in IOT-enabled board, Drone and Artificial Intelligence:

1. Design layout and component details of IoT-enabled board

The Arduino R3 schematic diagram is shown below. The pin connections are described as follows:-

- A0 pin is connected to the LM 35 sensor.
- A1 pin is connected to MQ-4 Gas Sensor.
- A2 pin is connected to Humidity Sensor.
- A3 pin is connected to Soil Moisture Sensor.
- 0 and 1 pin are connected to ESP32 for wireless connection.
- Pin 4 and Pin 5 is connected to alarm and DC motor respectively.

Power Supply is connected to give supply and LCD screen is there to display the switched on and currently working pin to chip.

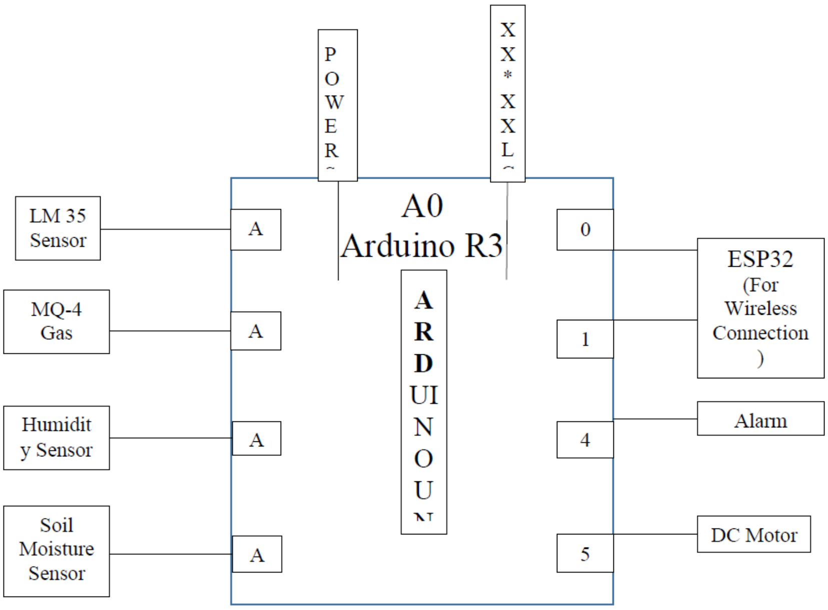

Fig. 2 Artitecture of Smart Board

2.2.1.1 Detail of the Components used for Smart Farming

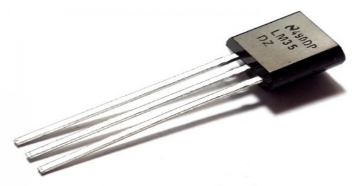

Fig. 3 LM35 Sensor

- Pin 1 – 4-20V
- Pin 2 – Out
- Pin 3 – In

Features:-

- Low-cost due to wafer level trimming.
- Operates from 4-20V
- Rated for full -55**°C to 150°C**
- Calibrated directly in Celsius

Fig. 4 MQ-4 Gas Sensor.

- VCC- Powers the module
- GND- Used to connect the module to ground
- Digital Out (DO) - Digital output can be attained from this.
- Analog Out (AO) – Outputs 0-5V analog voltage based on intensity of gas

Features:-

- Detects Natural gas and methane
- Operating Temperature 14° to 122°F
- Power Requirement VCC +5V

- Highly sensitive to Methane and Natural Gas
- Small sensitivity to Smoke
- Power Supply: 3.3-5v
- Current 2.5mA max current during conversion
- Humidity 20-90%
- Temperature 0-50°

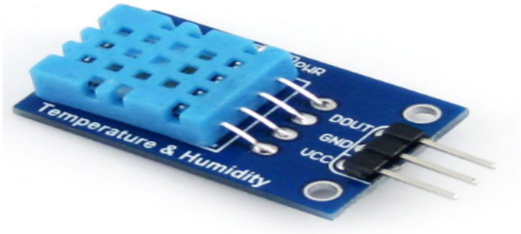

Fig. 5 Humidity Sensor.

Application- Irrigation techniques like drip irrigation need accurate moisture content for plants. Also, the moisture in the soil plays an important role in the proper growth of the plant. Other area where humidity control is required is indoor vegetation.

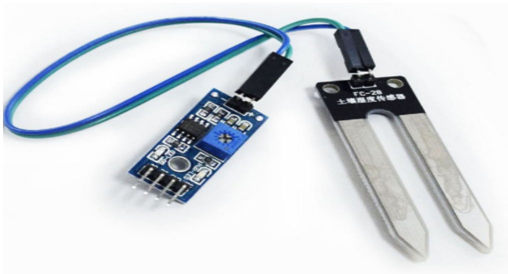

Fig. 6 Soil Moisture Sensor.

- Input Voltage: 3.3-5V
- Output Voltage: 0-4.2V
- Input Current: 35mA
- Output Signal: Analog and Digital Both

Application- Measuring soil moisture is important for agricultural applications to help farmers manage their irrigation systems more efficiently. Knowing the exact soil moisture conditions on their fields, farmers will not only able to use less water to grow a crop, they will also be able to increase yields and the quality of the crop by improved management of soil moisture during critical plant growth stages.

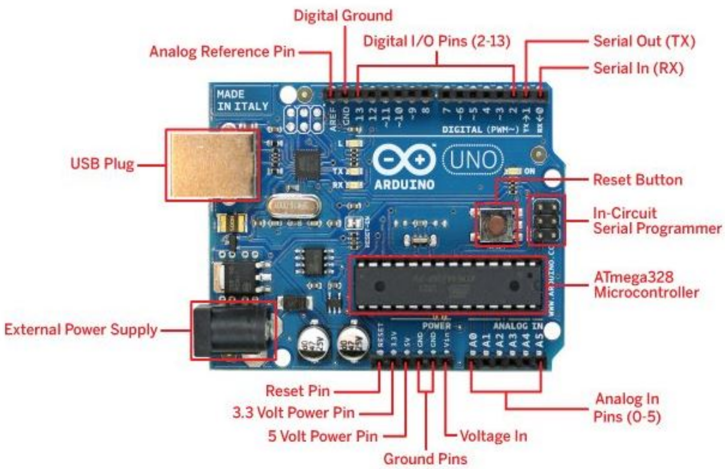

Fig. 7 Arduino UNO R3.

- Analog I/O Pins- 6
- Clock Speed- 16 MHz
- Color- Blue
- DC Current per I/O Pin- 40 mA;
- DC Current for 3.3V Pin: 50 mA

- Digital I/O Pins- 14 (of which 6 provide Pulse width modulation output)
- EEPROM- 1 KB (ATmega328)
- Flash Memory- 32 KB (ATmega328) of which 0.5 KB used by boot loader
- Input Voltage (Recommended)- 7-12V

Description:-

- 14 digital I/O pins, of which 6 (D3, D5, D6, D9, D10, and D11) can be used as Pulse width modulation outputs.
- 6 analog inputs, which can also be used as digital I/O pins, adding to the existing 14 digital I/O pins.
- Only one serial communication line (D0, D1)

Operations:-

The 14 digital input/output pins can be used as input or output pins by using pinMode(), digitalRead() and digitalWrite() functions in Arduino programming. Each pin operate at 5V and can provide or receive a maximum of 40mA current, and has an internal pull-up resistor of 20-50 KOhms which are disconnected by default.

Fig. 8 NodeMcu ESP8266.

Brief Study:-

The ESP8266 (Fig 3) is a very powerful and famous Wi-Fi Module which is also popular in the Internet of Things world. The microcontrollers can access the Wi-Fi network with the ESP8266 that is integrated with TCP/IP protocol stack. The storage capabilities of the ESP8266 are very powerful and sometimes are integrated with the sensors. The ESP8266 is embedded with a self-calibrated RF that allows it to work under all the operating conditions, hence it supports the VoIP applications and Bluetooth co-existence interfaces and requires no external parts.

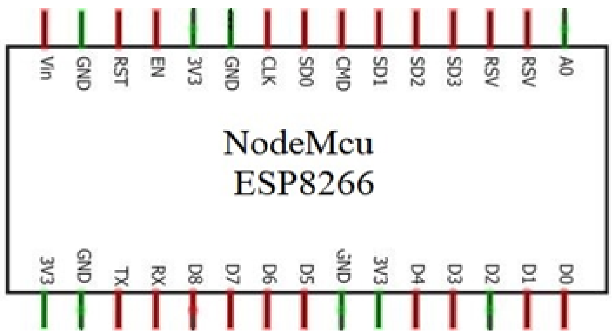

Fig. 9 NodeMcu 8266.

Features of the ESP8266 Wi-Fi Module

- Wi-Fi Direct (P2P), soft-AP
- Integrated TCP/IP protocol stack.
- Integrated TR switch, LNA, power amplifier.
- Power down leakage current of <10uA.
- 1MB Flash Memory.
- 2 x virtual Wi-Fi Interface.

2. Design of Drone Mainly Consist of Following Steps

A) **Selection of circuit design parameters to meet out the project objectives.**

i. Microcontrollers for flight control
ii. Sensor Module
iii. Electronic speed controllers
iv. Rotors (in runners and out runners)
v. Radio controllers
vi. Camera (Rx and Tx) module

vii. On-board power distribution board

B) **Verification of Physical Design**

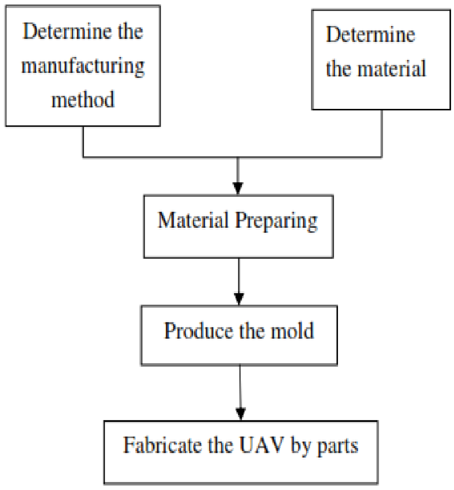

Fig. 10 Flow of Verification of Physical Design.

C) **AutoCAD design of prototype for safety and free fall drop test.**

D) Selection of material (depending on mass distribution, durability & weight management)

E) Selection of Rotors, Propellers and Battery Capacity (depending on gross drone dry weight and pay load capacity) (R&D).

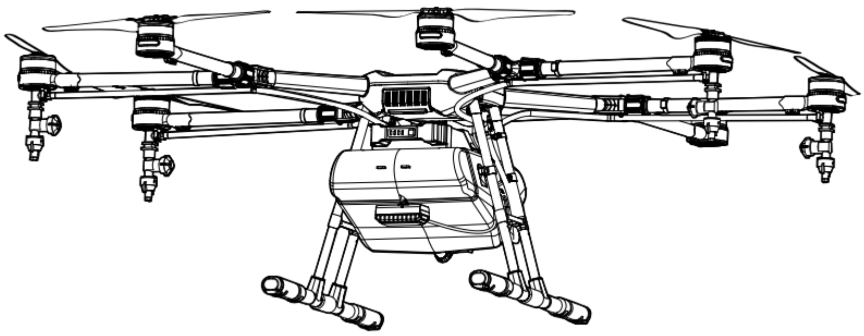

Fig. 11 Octa-Rotor configurations of agriculture drone system.

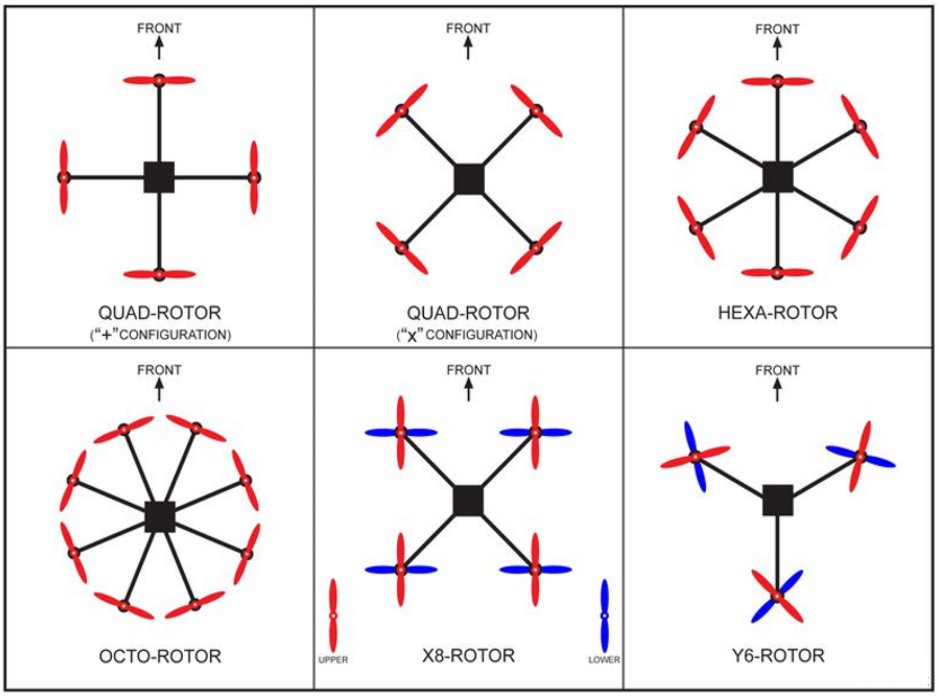

Fig. 12 Various configurations of rotor for different applications.

F) Setting up the power distribution board (R&D).

G) Setting up the flight controller (R&D)

H) Selection of electronic speed controllers (depending upon the power consumption of rotors)

I) Method of communication (PWM, I2C, USART, SBUS).

J) PID Tuning and calibration of flight controller.

K) Designing of Antenna (R&D).

L) Setting up the radio controller.

M) Setting up the camera module (including on board transmitter and receiver(cloud))

N) Powering the system by Lithium-Polymer battery.

O) Calibrating and synchronising the controller with rotors.

P) Complete testing on drone to AI server communication network.

Q) **List of** Hardware **Components Used in Drone Design and Fabrication:**

i. Propellers

ii. Frame arms

iii. Motors

iv. Orientation indicators

v. Sprinklers

vi. Nozzles

vii. Hoses
viii. Landing Gears
ix. Pumps Motor Cable
x. Pumps Motor
xi. Delivery Pumps
xii. Spray Tanks
xiii. Aircraft Status Indicator
xiv. Aircraft body
xv. GPS Module
xvi. Motor Port
xvii. Flight Controller Data Port (Micro USB)
xviii. Intake Vent
xix. Power Port
xx. Battery Compartment
xxi. Radar Module
xxii. Radar Cables
xxiii. Remote Controller Holder
xxiv. On screen display port
xxv. Radar port
xxvi. Sensors for various application.

3. Detection of plant leaf diseases using Machine Learning and Internet of Things

Andrew NG truly said "It is difficult to think of a major industry that AI will not transform. This includes healthcare, education, transportation, retail, communications, and agriculture. There are surprisingly clear paths for AI to make a big difference in all of these industries."

Earlier, the news about farmers committing suicide because of devastation of plants due to diseases was known to everyone. In a country like India where Agriculture and allied sector is one of the major employment resources, Agriculture plays a vital role in the Indian economy. Over 70 per cent of the rural households depend on agriculture. Agriculture is an important sector of Indian economy as it contributes about 17% to the total GDP and provides employment to over 60% of the population.

The prevention and control of plant disease have always been a topic of curiosity because plants are exposed to outer environment and are highly prone to diseases. Normally, the accurate and rapid diagnosis of disease plays an important role in controlling plant disease, since useful protection measures are often implemented after correct diagnosis.

Disease can negatively impact plant health before any visible signs like leaf discolouration show.

Our project basically aims at detection of plant disease with the help of an Unmanned Aerial Vehicle (UAV), a drone which could fly over the farm with an embedded camera in it, could capture the frames and then send the data to our database. The data will then be fetched to our trained model and hence will diagnose the disease. Diseases which can be easily diagnosed by this initiative are as follows.

a. **Leaf Spots**

Leaf spots (other names: anthracnose, scab, leaf blotch, shot hole) are usually rather definite spots of varying sizes, shapes and colours. There is nearly always a distinctive margin. Sometimes the spot, which may be caused by bacteria or fungi, is surrounded by a yellow halo. If caused by a fungus, there is nearly always fungus growth of some type in the spot, particularly in damp weather. This fungus growth may be tiny pimple-like structures, often black in color, or a moldy growth of spores. It is often necessary to use a hand lens or a microscope to see these structures. If the spots are numerous or close together, diseased areas may join together to form irregular areas called "blotches." The common names of leaf spot diseases may be general, such as bacterial leaf spot; descriptive, such as frog-eye leaf spot; or named after the fungus, such as Septoria leaf spot.

b. Leaf Blights

Leaf blights are generally larger diseased areas than leaf spots and more irregularly shaped. Sometimes the "blighting" appearance of leaves is the result of the coalescence of numerous small spots. Usually the common name includes the word "blight" such as Southern corn leaf blight or early blight.

c. **Rusts**

Rusts often produce spots similar to leaf spots, but the spots are called "pustules." Rust pustules are bright yellow, orange-red, reddish-brown or black in color. The pustules are usually raised above the leaf surface, and, when rubbed with a white cloth, a colored deposit the same color as the pustule can usually be seen on the cloth. In severe cases, the leaf withers and dies rapidly. Some types of rust also occur on stems. Rusts are common on grains and grasses.

d. **Powdery Mildew**

Powdery mildew is a superficial, white to light grayish, powdery to mealy growth on leaves, but may also occur on stems and flowers. Affected leaves usually turn yellow, wither and die rapidly. The problem is common on cucurbit-type vegetables and on small grains.

e. **Downy Mildew**

Downy mildew symptoms are pale yellow green to yellow areas on the upper leaf surface; light gray to purplish moldy growth on the under surface of the leaf. Blue mold of tobacco is a downy mildew disease. Deformed plant growth ("crazy top") may result from downy mildew as in the case of sorghum downy mildew of corn or grain sorghum.

2.2.3.1 Algorithm and Methodology:

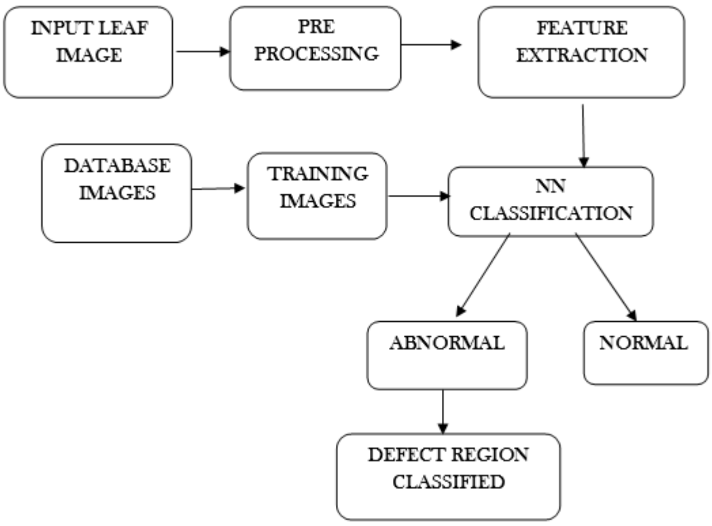

Fig. 13 Various configurations of rotor for different applications.

Step1: The leaf image will be taken by the camera which is embedded on the drone, there will be boards located under the crust of the farm land which would transmit the basic data values like soil moisture, temperature and pH.

Step 2: The images as well as the features of the soil will be sent to our database, using the concept of Internet of Things. Here we will be using A key IP (Internet Protocol)-based technology is 6LowPAN (IPv6 Low-power wireless Personal Area Network) and Celluar GSM Service 4G/5G.

Step 3: The test data will then be first pre processed and then will be sent to our trained model or hypotheses. Here we will use Open CV (Computer Vision).

Step 4: Our hypotheses will tell us where the leaf is normal or abnormal, and hence it is diagnosed.

2.2.3.2 Flow Chart of Complete Integrated System

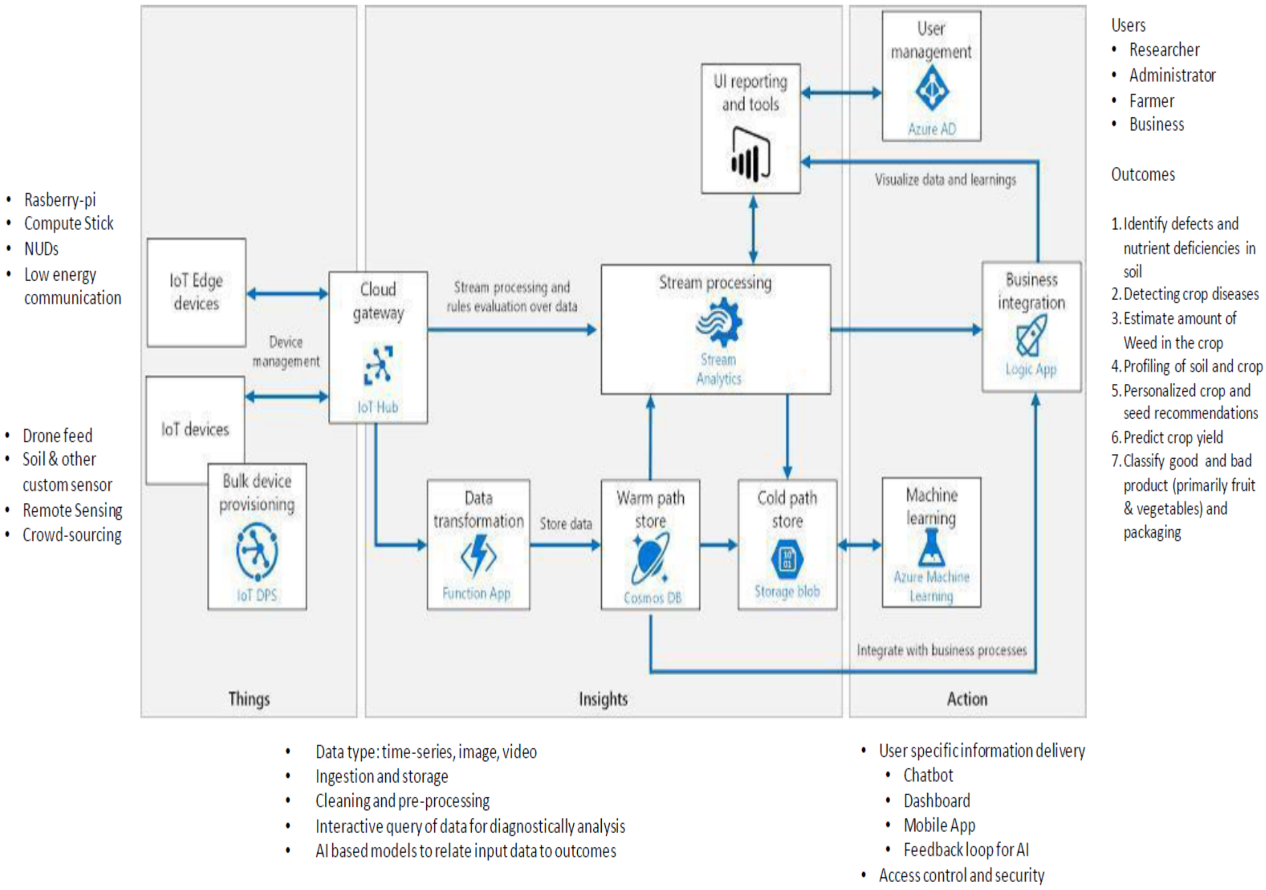

Fig. 14 Various configurations of rotor for different applications.

There are three sections : 1) Things 2) Insights Engine 3) Actionable and Reinforcement

1) Collection of data mainly two types from data sources :

a) IoT Edge :

- Rasberry-pi
- Compute Stick
- NUDs
- Low energy communication

b) IoT DPS and Devices :

- Drone feed
- Soil & other custom sensor
- Remote Sensing
- Crowd-sourcing

2) Data is transferred from 1st section to 2nd section through the cloud gateway which is essentially the IoT Data Hub. The insights engine does the following:

- Data type: time-series, image, video
- Ingestion and storage
- Cleaning and pre-processing
- Interactive query of data for diagnostically analysis
- AI based models to relate input data to outcomes

3) The action engine uses the insights to :

- User specific information delivery
    - Chatbot
    - Dashboard
    - Mobile App
    - Feedback loop for AI
- Access control and security

Different UIs can be for different users like

- Researcher
- Administrator
- Farmer
- Business

Lastly, the following outcomes are delivered out of this :

- Identify defects and nutrient deficiencies in soil.
- Detecting crop diseases
- Estimate amount of Weed in the crop
- Profiling of soil and crop
- Personalized crop and seed recommendations
- Predict crop yield
- Classify good and bad product (primarily fruit & vegetables) and packaging